<u>I CLAIM</u>:

1. Non-destructive testing apparatus, comprising:

a photon source, said photon source producing photons having a predetermined energy and directing the photons toward a specimen being tested, the photons from said photon source resulting in the creation of positrons within the specimen being tested; and

a detector, said detector positioned adjacent the specimen being tested so that said detector detects gamma rays produced by annihilation of positrons with electrons, the gamma rays produced by the annihilation of positrons with electrons being indicative of a material characteristic of the specimen being tested.

2. The non-destructive testing apparatus of claim 1, wherein said photon source comprises a source of bremsstrahlung photons.

3. The non-destructive testing apparatus of claim 2, wherein said source of bremsstrahlung photons comprises:

an electron accelerator, said electron accelerator accelerating a stream of electrons to a predetermined energy; and

a target operatively associated with said electron generator, said target intercepting the stream of electrons from said electron accelerator and producing photons.

4. The non-destructive testing apparatus of claim 1, wherein said photon source comprises an isotopic photon source.

5. The non-destructive testing apparatus of claim 1, wherein said detector comprises a germanium detector.

6. The non-destructive testing apparatus of claim 1, further comprising a data processing system operatively associated with said detector, said data processing system processing data from said detector to produce human-readable output data indicative of the at least one material characteristic of the specimen.

7. The non-destructive testing apparatus of claim 6, wherein said data processing system is operatively associated with said photon source, said data processing system operating said photon source to produce photons having the predetermined energies.

8. Non-destructive testing apparatus, comprising:

photon generating means for producing photons having predetermined energies and for directing the photons toward a specimen being tested, the photons from said photon generating means resulting in the creation of positrons within the specimen being tested; and

detecting means for detecting gamma rays produced by annihilation of positrons with electrons within the specimen being tested and for producing an output indicative of a material characteristic of the specimen being tested.

9. A method, comprising:

producing photons having energies within a predetermined energy range;

directing the photons at a specimen to be tested, the photons resulting in the creation of positrons within the specimen being tested; and

detecting gamma rays produced by annihilation of positrons with electrons within the specimen.

10. The method of claim 9, further comprising determining a material characteristic of the specimen based on the detected gamma rays.

11. The method of claim 9, wherein the step of producing photons comprises:

accelerating electrons to electron energies within a predetermined electron energy range; and

directing the electrons toward a target, the target producing photons in response to bombardment by the accelerated electrons.

12. The method of claim 9, further comprising:

determining whether the specimen being tested will produce at least one positron emitter therein in response to photon bombardment;

selecting a positron emitter to be produced;

determining a photon energy required to produce the selected positron emitter; and

setting the predetermined energy range so that it encompasses the photon energy required to produce the selected positron emitter.

13. The method of claim 12, further comprising:

determining a half-life of the at least one positron emitter; and

alternately activating the at least one positron emitter and detecting gamma rays produced by annihilation events when the half-life of the at least one positron emitter is less than a selected half-life.

14. A method, comprising:

providing a specimen comprising at least one positron emitter;

determining a threshold energy for activating the at least one positron emitter;

activating the at least one positron emitter by bombarding the specimen with photons having energies at least as great as the threshold energy; and

detecting gamma rays produced by annihilation of positrons and electrons within the specimen; and

determining a material characteristic of the specimen based on the detected gamma rays.

15. The method of claim 14, wherein the step of activating comprises:

producing photons a portion of which have energies at least as great as the threshold energy; and

directing the photons at the specimen.

16. The method of claim 14, further comprising determining a positron lifetime based on the detected gamma rays.

17. The method of claim 14, further comprising using a Doppler broadening algorithm to determine the at least one material characteristic.

18. The method of claim 14, further comprising using a three dimensional imaging algorithm to determine a position within the specimen of a positron/electron annihilation event.

19. A method, comprising:

providing a specimen comprising at least one positron emitter;

determining a threshold energy for activating the at least one positron emitter;

determining whether a half-life of the at least one positron emitter is less than a selected half-life;

when the half-life of the at least one positron emitter is greater than or equal to the selected half-life:

activating the at least one positron emitter by bombarding the specimen with photons having energies greater than the threshold energy; and

detecting gamma rays produced by annihilation of positrons with electrons within the specimen; or,

when the half-life of the at least one positron emitter is less than the selected half-life:

activating for an activation time the at least one positron emitter by bombarding the specimen with photons having energies greater than the threshold energy;

detecting for a detection time gamma rays produced by annihilation of positrons with electrons within the specimen; and

repeating said steps of activating for an activation time and detecting for a detection time until detecting a sufficient number of gamma rays to determine at least one material characteristic of said specimen.